ABSTRACT

Due to rapid shrinking and increased heat flux density, effective thermal management in tiny systems such as microelectronics, MEMS, and biomedical devices has become increasingly important. Because of its great surface area to volume ratio and efficient convective heat transfer properties, micro-channel heat sinks have become a potential approach for high-performance thermal management. Conventional micro-channel designs still suffer in thermal performance, nevertheless, from laminar flow regimes and boundary layer formation. Using Computational Fluid Dynamics (CFD), this thesis examines the improvement of heat transport in micro-channels under constant and pulsating flow conditions. The influence of pulsation frequency, amplitude, and waveform on flow behaviour and thermal performance is investigated in this work therefore offering a thorough knowledge of flow-thermal interactions at the microscale.there are six chapters form the thesis. Microscale heat transmission, the value of micro-channel technology, and the function of flow pulsation in thermal enhancement are thoroughly reviewed in Chapter 2. The chapter also points out current research gaps and drives the necessity of a computer analysis.

Together with the modelling assumptions, Chapter 3 shows the governing equations for heat transfer and fluid flow. The finite volume method (FVM) is the foundation of the numerical technique applied; ANSYS Fluent is used for simulations. Reliability and accuracy of the model are guaranteed by thorough grid independent investigation and validation using benchmark previous literature data.

Using water as the coolant, Chapter 3 addresses the baseline investigation of heat transport in a 2D micro-channel under constant flow circumstances. We investigate in particular how Reynolds number affects Nusselt number, friction factor, and temperature distribution.

Chapter 5 presents flow pulsation into the 3D micro-channel and assesses their effect on thermal and hydrodynamic performance. The work explores a spectrum of pulsation frequencies and amplitudes, emphasizing the regimes whereby pulsation greatly increases the convective heat transfer without causing a major pressure penalty. Also, the chapter investigates pulsing flows the performance of micro-channels with geometric modifications. I investigate synergistic thermal increase techniques by means of the combined influence of geometry-induced turbulence and flow pulsation.

Chapter 6, at last, compiles the main conclusions and contributions of the investigation. It emphasizes that depending on the flow parameters and waveform, pulsing flow can increase the Nusselt number by up to 30–45%. This improvement is accompanied, nevertheless, by a pressure decrease that has to be tuned depending on the intended use.

This work presents insightful analysis of micro-channel heat sink design and optimization for high-performance uses. Engineers and designers hoping to apply active flow control techniques in small-sized thermal systems might find direction in the results. Future research could use phase transition materials or nano-fluids to improve performance even further.